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Energy Saving Transmission for Green Communication

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Abstract: **Green Communication helps us in providing an Eco-friendly environment. The vast requirement and development of Green Communication leads to energy saving transmissions. As more than one Component Carrier (CC) can be jointly utilized in Base Station (BS), the energy consumption of BS is a vital concern. In this paper we propose a technique for energy- efficient data transmission. We use two CCs and it supports both Real Time (RT) and Non-Real Time (NRT) users. In the downlink transmission, Orthogonal frequency division multiple access based carrier components are considered. Simulation results show the energy consumption of the proposed system is much better when compared with the existing systems.**

Keywords: **Green Communication, OFDMA, energy efficiency, eco-friendly environment, Radio Resource Allocation**.

I. INTRODUCTION

The cellular communication industry has witnessed explosive growth. The telecommunication world is opted to be the main cause of consumer of energy and took place as the major participant in the emission of Carbon footprints in to atmosphere and enormous consumption of energy by networks. Hence energy efficient communication attracts attention towards it. It is spotlighted that the total energy devoured by the communication networks and the internet is above 3% of the world wide electric consumption and is anticipated for a rapid increase in future [1].

Telecommunication sector has about 6 million subscriptions in the world [2] and 2% of the total emission of CO_2 [3]. The production of 0.75 million tons of CO_2 for every 1 terawatt hour (TWh) energy consumption [4] are due to ICT sectors and is increased twice for every five years [5]. In order to prevent the rise in global temperature less than 2^{o} C, it is essential for reduction in the emission rate of CO_2 up to 15% to 30% [6]. It is estimated that the worldwide energy swallowed by internet is equal to energy produced from 14 power stations [7]. This leads to the increase in global warming. Global warming is described as increase in the average temperature of Earth's atmosphere. Scientists are 95-100% sure that it is primarily occurred by increasing applications of greenhouse gases produced by human activities such as the blazing of fossil fuels, deforestation, etc.

The CO_2 is also released by the base stations during transmission and reception of signals. The remedy for this is to use the green communication; its core tenant is to reduce the overall energy consumption. It is a highly innovative technology that offers a cost-effective solution to the needs of Wi-Fi coverage in crowded public places. Eco-friendly environment; lessen carbon foot print in the atmosphere and there by lower the global warming in our Earth are some of its merits.

A rate adaptive resource allocation method for Multi-User Orthogonal Frequency Division Multiplexing (MU-OFDM) is proposed in [7]. [8] Says about the implementation of efficient algorithm for allocating sub carriers and power among users for multi user orthogonal frequency division multiplexing. Quantized water filling packet scheduling algorithm for high data rate nomadic users has been proposed in [9]. A technique for dynamic power adjustment to enable energy efficient data transmissions by utilizing only necessary transmission power is proposed in [10]. A Holistic approach for energy efficient radio networks by using 3 levels of mutual supplementary saving concepts have been proposed in [11]. Radio resource management schemes like Connection Admission Control (CAC) and Packet Transmission Scheduler (PTS) which are the two levels of it is proposed in [12].

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II. SYSTEM MODEL

A. *Basic Assumptions:*

In a single cellular network, the downlink load is higher when compared to the uplink load. Hence, the downlink transmission is taken into consideration. This concept is implemented in BS. Two CCs can be used by the BS at the same time. They are classified as Primary Component Carrier (PCC) and Secondary Component Carrier (SCC). PCC is given first priority for each

transmission. Whenever the PCC is found to be busy, the transmission is performed by using the alternate CC i.e. the SCC. The bandwidth of each CC is in Hz. The total bandwidth is divided into N sub channels and each sub carrier in sub channel suffers from the same amount of fading. A group of M OFDM signals is called as a single frame and the channel state in each frame is maintained fairly stable.

B. *Block diagram and its description:*

The classifier is used to classify the incoming session as Real Time (RT) and Non-Real Time (NRT) sessions. The classified RT and NRT sessions are queued in the separate queues.

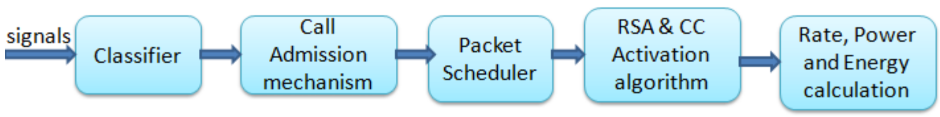

Figure 1: System Flow

C. *Call Admission Mechanism:*

The admission control mechanism is used to judge whether the session is to be blocked in the scheduling queue or allowed to the next block. It is also used to determine the correct CC to be assigned to the session when it is allowed to the network.

ALGORITHM:

1. Compare the energies $E_k < \rho E_{max}$
   Where
   E_k – Energy of K_{th} carrier
   E_{max}– Maximum available energy in each sub frame
   ρ - Upper Marginal Factor
2. If (1) is yes
   Check the SCC status whether it can be used.
   Else
   Block the session and return.
3. PreOnFlag - indicator; to determine whether the new user session can access SCC
   PreOnFlag = 0; can't access SCC
4. If (3) is yes
   PCC can be used when N_1<S.
   Else

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CC k* with minimum E_k is selected and check N_{K*}<S.

Where, N- Sessions number

S- total number of Sessions

5. If (4) is yes

   Assign the session to CC1

   Else

   Block the session and return.

6. When the Else condition of 4 is performed

   Assign the session to CC K*

   Else

   Check $(N_k < S)$ && $(E_k < E_{max})$.

7. If the Else condition of 6 is performed

   Assign the session to CC K*

   Else

   Block the session and return.

The output of the Admission Control Mechanism is given as the input to the next block.

D. Packet Scheduler:

It decides the transmission priority of packets and then rate requirement of each user which is used in RSA. It matches with the characteristics of both packet data system and OFDM. It gives priority to the RT packets only under emergency conditions.

$$Emergency\ factor = \frac{Waiting\ time\ of\ a\ packet\ in\ MAC\ queue}{Delay\ constraint\ of\ a\ packet}$$

In packet data system, the amount of queued data for a user with bad channel condition is generally large. The amount of resources is also large. The scheduler restricts the amount of resources given to a user and controls the number of user served in a frame, for maximizing the utilization and multi-user diversity gain.

The capacity of the frame is calculated only when the resources are allocated to user. The scheduler estimates the number of Auxiliary Units to exhaust data to each user assuming that each user is given a sub channel with best channel quality.

1. scheduling process

It has 3 stages. The procedure is passed to the next stage if there is available number of Aus at the end of each stage. The rate allocation for each user in each state is the required rate allocation for resource allocation.

1.1 Stage 1:

It is used for scheduling urgent packets. The user whose waiting time of head of line pack is closer to delay constraint is given the high priority.

$$Required\ AUs = \frac{u_k}{b_{k,max}}$$

u_k - Volume of Urgent data

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$b_{k,max}$ - Highest transmission rate per Au of user

1.2 Stage 2:

This stage is used for scheduling NRT and RT packets which are not urgent. The user with better average channel quality regardless of traffic type is given higher priority.

1.3 Stage 3:

The remaining available Aus are scheduled to users who need more Aus than restriction. When the number of user is equal to 1 then this stage is not needed. The scheduling order is decided according to the number of Aus required additionally.

E. Resource Scheduling Algorithm (RSA):

It includes 2 Algorithms, they are

- Energy Adaptive Rate Control Algorithm (EARCA)
- Radio Resource Allocation Algorithm (RRAA)

1. *Energy Adaptive Rate Control Algorithm (EARCA):*

It is used to maintain the fairness among the users in certain level. The design approach of EARCA:

1. Large NRT users are placed in a cell.
2. RB's are allocated based n PF criterion and equal power is allocated in each RB.
3. Average data rate as a function of path loss gain is calculated.
4. Natural log function based on minimum mean square filtering method is obtained.
5. Normalize the natural log function so as the reduction ratio of NRT user having maximum channel gain equals to 1.

2. Radio Resource Allocation Algorithm (RRAA):

RRAA is designed on the basis of Resource Allocation Approach in the beginning of decision epoch in every sub frame. The two sub algorithms of RRAA are as follows.

- Bandwidth Allocation Algorithm (BAA)
- Resource Block Allocation Algorithm (RBAA)

2.1 Bandwidth Allocation Algorithm (BAA):

It is used to determine that how many RB's should be assigned to each user session. The algorithm is as follows:

1. User feedbacks the channel gain to the base station so that the averaged square channel gain is calculated as input arguments.
2. Number of required R's is '0' for all users initially.
3. To guarantee minimum data requirements 1 RB is given to all users.

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4. Remaining RBs are allocated according to allocation metric.
5. The user which has decrease in energy consumption after allocating RB's will be given another RB.
6. After allocation, the number of required RBs for the selected user will be added by 1.

After BAA; RBAA is executed subsequently

2.2 Resource Block Allocation Algorithm (RBAA):

The algorithm for the RBAA is described as follows.

1. Find the user who has huge channel gain
2. Examine whether, Number of current allocated RBs of user is equal to Number of required RBs.
3. If (2) is yes

   Find another user with largest channel gain till while loop is over.
4. After while loop, allocate RB to the user session picked in this run.

After executing the two sub algorithms, the following steps are carried out.

- RBs for every user session is determined
- Data rate of each user session is equally distributed over all allocated RBs.
- Energy for each RB is determined.

3. *Component Carrier Activation Algorithm (CCAA):*

The component carrier activation algorithm is used to determine the practical use of SCC according to fluctuating network traffic load to conserve main energy consumption of Base Station (BS).

III. SIMULATION RESULTS

8 users, using 10 sub channels each with 1 MHz frequency is taken into consideration.

1. CLASSIFIER OUTPUT:

The classifier classifies the signal into Real Time Signals and Non Real Time Signals. The signals with high frequency are classified as the RT signals and the rest of the signals are classified as NRT signals.

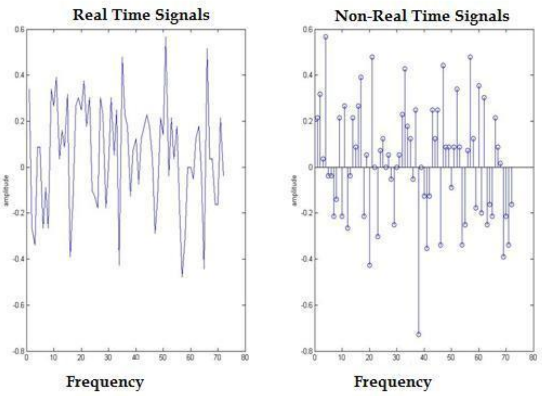

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Figure 2: Classified RT and NRT signals

The signals are then sent to the respected scheduling queues. The queue is generally in the form of FIFO where the first incoming signal is delivered out first. The length of the queue is calculated and the queue which has the highest length is given the high priority.

2. Data Rate Calculation:

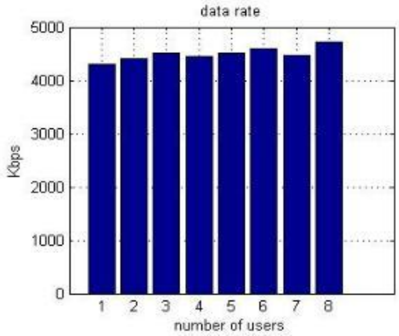

Figure 3: Data Rate Graph

The rate at which the signals are transmitted in the channel is calculated as the data rate, which can be calculated by dividing the number of bits transferred by the time taken by bits.

3. Fairness Index:

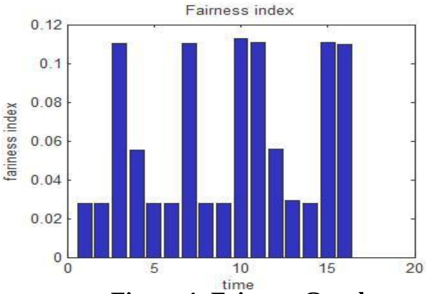

Figure 4: Fairness Graph

The fairness of the system must be always high as it determines the quality of service. It is calculated by dividing the channel capacity with the number of channels. The following figure shows as that the fairness is maintained considerably high when using our method. Fairness is defined as the amount of correct information received by the receiver from the sender. When the fairness is maintained at high level, the system is said to be an efficient system

4. Arrival Time:

The arrival time is calculated by dividing the total time by the product of number of channels and the number of samples. This arrival time is combined with the user and is plotted in the above graph. This arrival rate is used to in the scheduling queue in order to avoid congestion.

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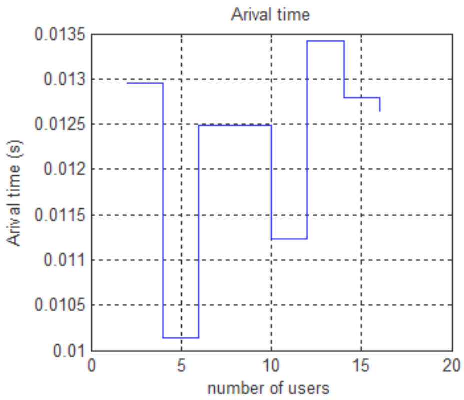

Figure 5: Arrival Time Graph

5. *Energy Consumption:*

The energy consumption of the signal is calculated by using the formula as follows:

$$y(n) = \left(\frac{x(n)}{f(n)}\right) * conj\left(\frac{x(n)}{f(n)}\right)$$

Where,
x(n)- input signal
f(n)- input signal frequency
y(n)- energy consumed

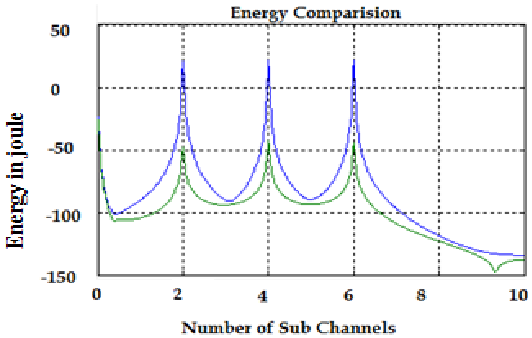

Figure 6: Energy Consumption Graph

It can be found out from the figure that the energy consumption by using the proposed method is much less when compared to the existing method.

IV. CONCLUSION AND FUTURE WORK

The OFDM signals are thus generated and the signals are classified into the Real Time and Non-Real Time signals. The classified signals are then prioritized in the scheduling queue in the FIFO basis which is then sent to the Admission Control mechanism. The output of which is sent to the Resource Scheduling Algorithm and Component Carrier Activation Algorithm. The energy of the signals are calculated and plotted in the graph. The simulation results clearly shows that the consumption of energy by the signal when sent using the existing method is much higher when compared with the energy consumed by the signal using the proposed method. In future it is planned to use MIMO combined with OFDM to reduce the amount of energy consumed by each Base station. Using MIMO we can improve the spectral efficiency and communication performance.

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BIOGRAPHY

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